

# Industry Day

# Netex

## Networking in Extreme Environments

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# Netex Objective

UWB systems have an advantage in short range high-multipath environments

***Develop Military Ultra Wideband (UWB) sensors and communications systems for operation in extreme environments***

- Gain understanding of the effects of UWB system operation on existing narrow band spectrum users
- Improve the physical layer design and functionality of UWB systems
- Enable non-cooperative UWB channel access
- Create UWB enhanced wireless routing protocols
- Develop multifunction waveform system

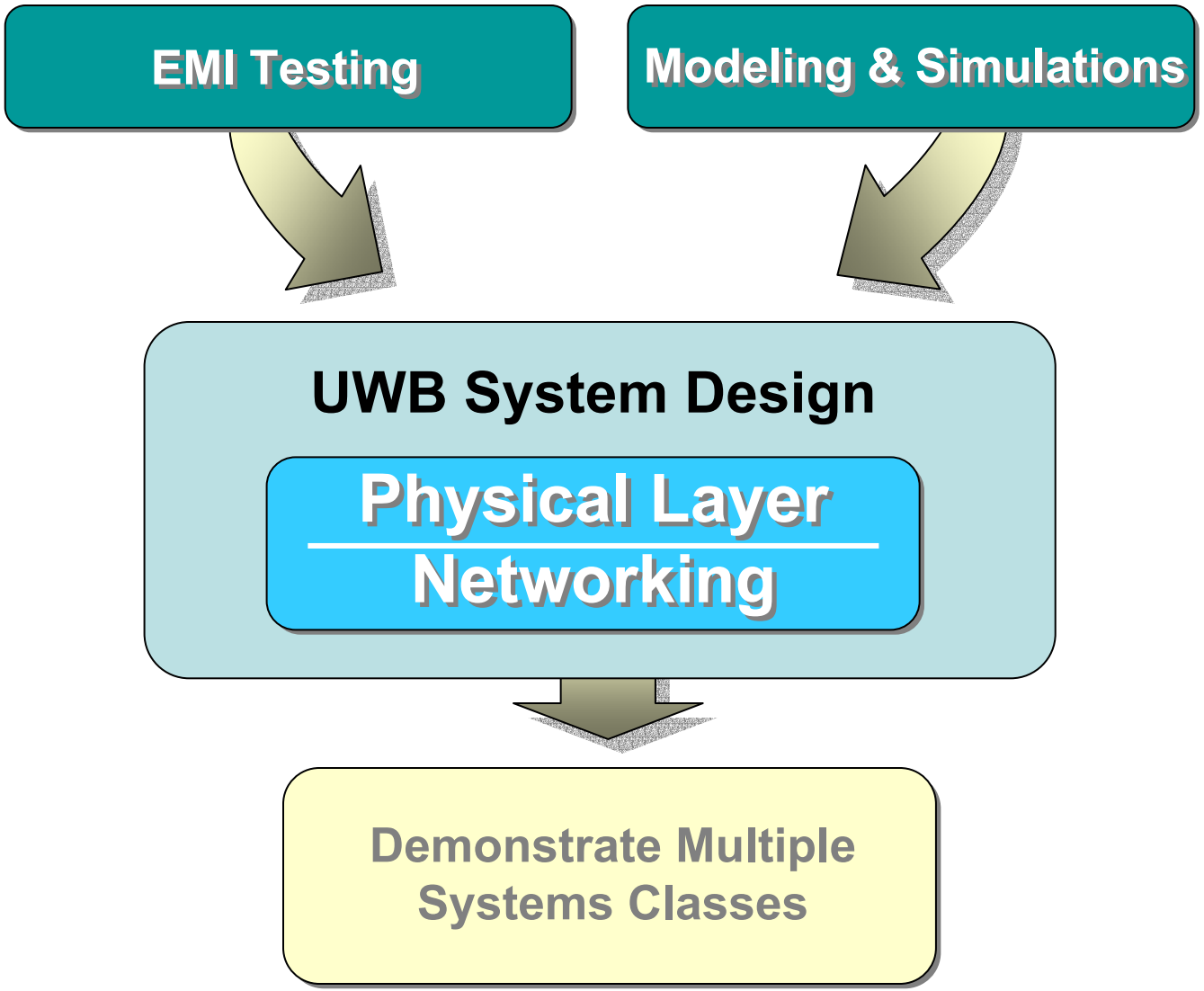
Deliver systems that exploit the unique benefits of the UWB physical layer to provide robust communications in complex terrain

# Task 1 UWB Understanding

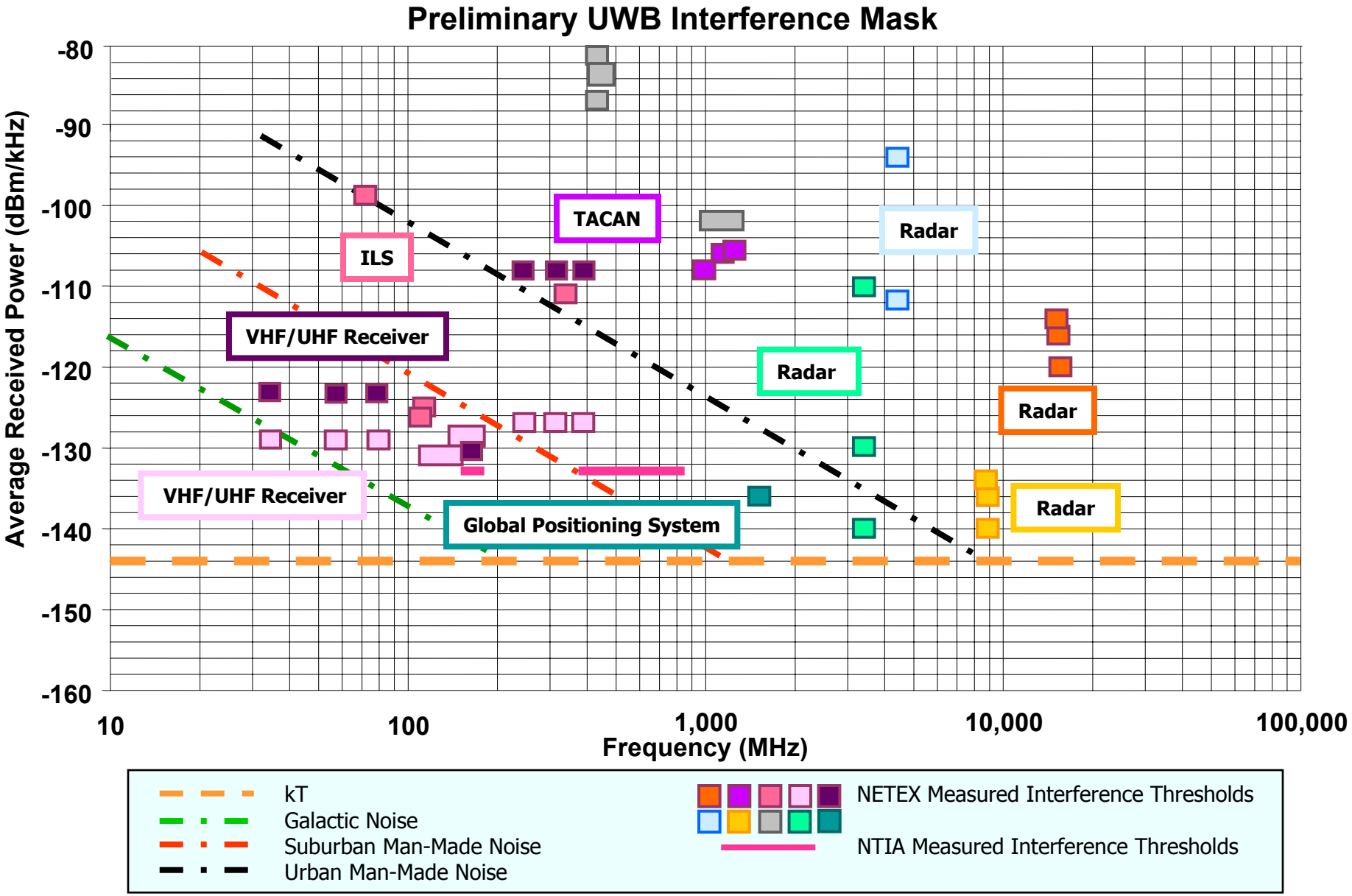
- Two track approach: EMI Testing and Simulations
- Select a team of impartial government agencies, labs, and universities to develop a standard UWB test methodology
- Provide the contractors access to state-of-the-art test and measurement facilities for experiments and tests

- Use modified MIL STD 461E & MIL STD 464 test procedures to conduct documented and repeatable measurements of UWB radiation (20 MHz to 25 GHz) on an assortment of military systems
- Verification of the models through real system tests

# Netex Program Framework



# Interference Study



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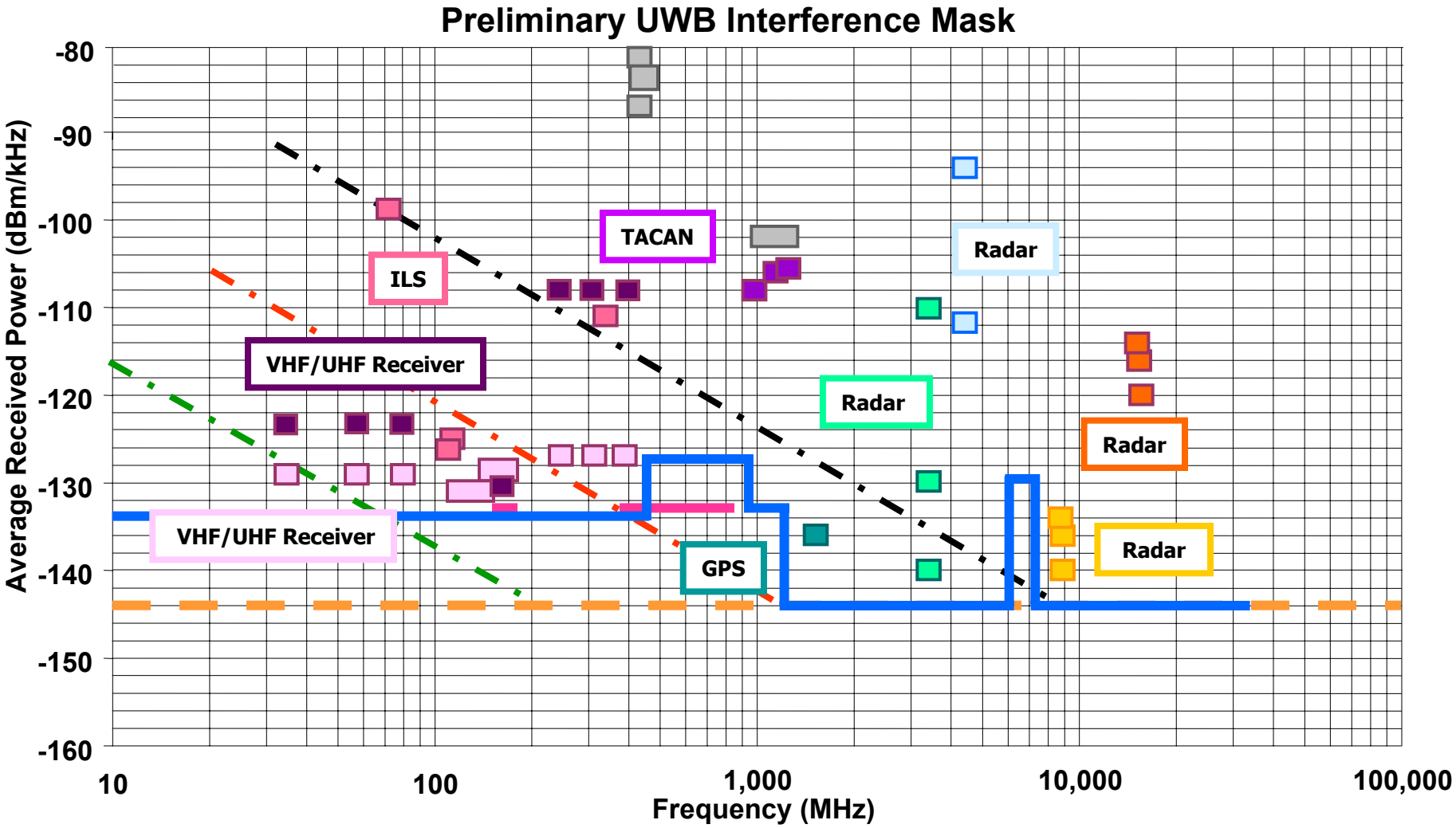

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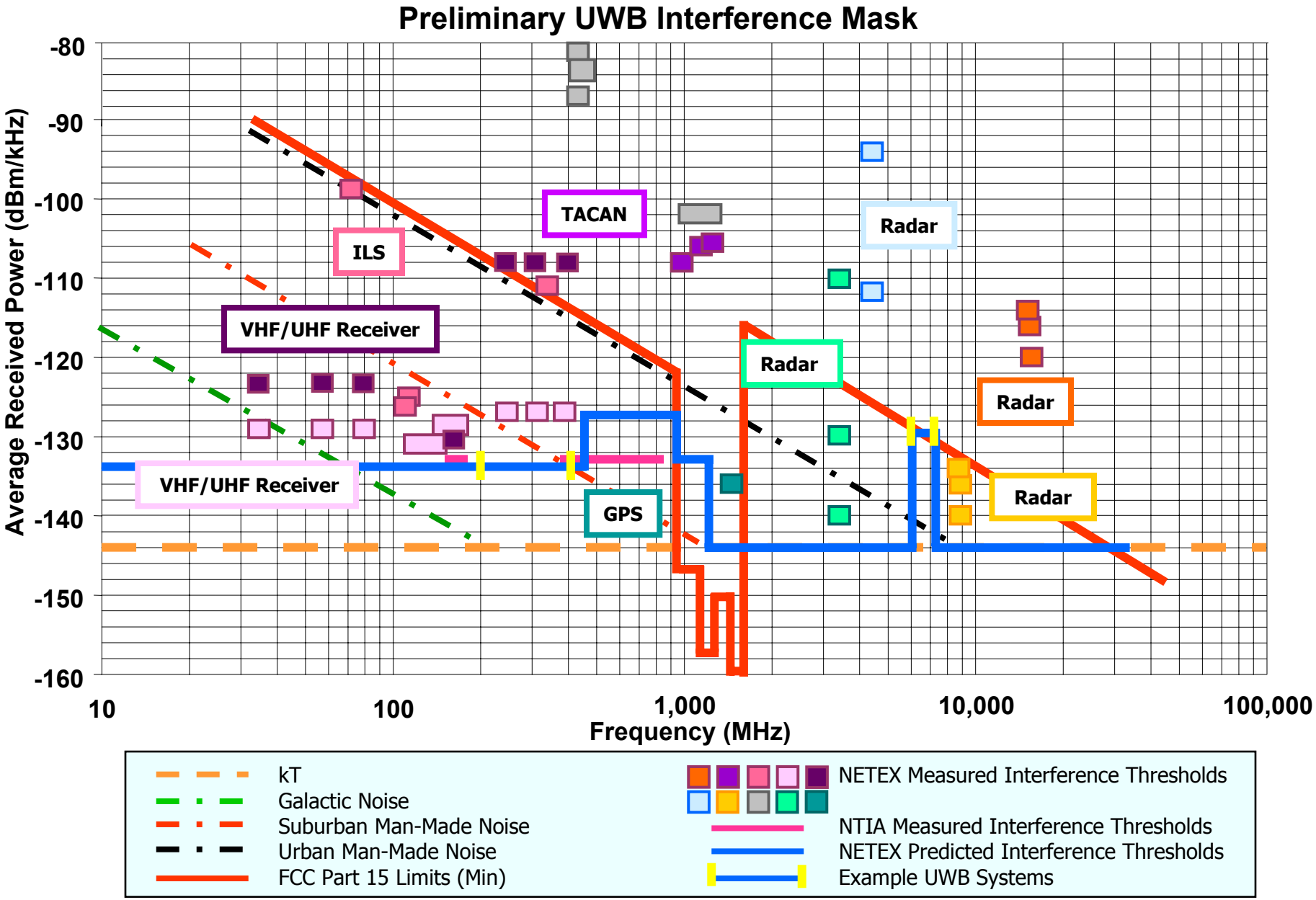

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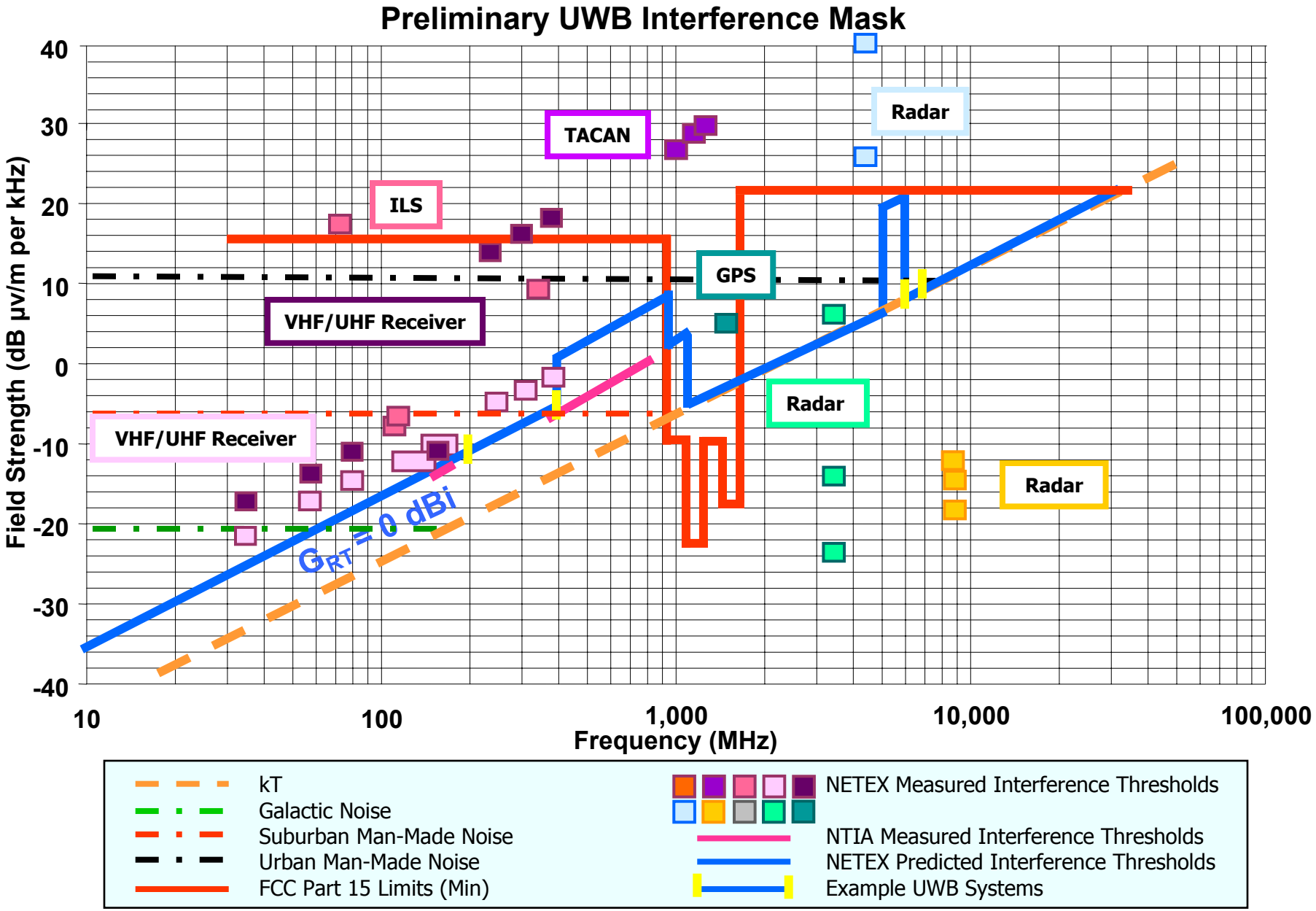


# Broad Range of Systems

***We can Design UWB Systems that Co-Exist with Legacy Receivers and Support Militarily Useful Functions…***

| System Type | Power dBm | Range meters | Data Rate | Freq | BW | S/N dB | I/N dB |
|---|---|---|---|---|---|---|---|
| Hand Held | 14 | 500 | 10 Kbps | 200-400 MHz | 200 MHz | 10 | 6 @ 20m |
| High Data / Short Range | 10 | 100 | 10 Mbps | 6 – 7 GHz | 1 GHz | 7 | -9 @ 10m |
| RADAR 1 $m^2$ | 40 | 500 | 10 Kpps | 6 – 7 GHz | 1 GHz | 2 | -21 @ 10m |
| Personnel RADAR 1 $m^2$ | 50 | 100 | 100 pps | 850 MHz | 300 MHz | 6.6 | 20 @ 10m |

Many Classes – Multiple Implementations

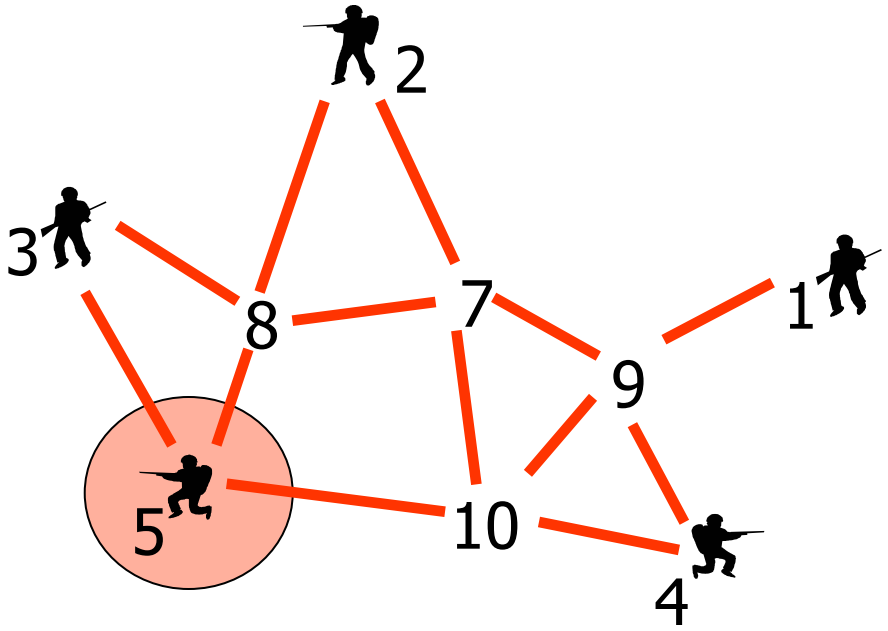
# Hand Held Communications

## UWB Link Data

| | |
|---|---|
| Range | 500 m |
| Data Rate | 10 kbps |
| S/N@ Max Range | 10 dB |
| Peak Power | 14 dBm |
| Pulse Width | 5 nsec |
| Center Frequency | 300 MHz |
| Bandwidth | 200 MHZ |
| Antenna Gain | 2 dB |
| Antenna Height | 2 m |
| System Loss | 1 dB |
| Noise Figure | 1 dB |

## EMI to Legacy Systems

| | |
|---|---|
| EMI Zone | 20 m |
| I/N | 6 dB |
| Noise Figure | 10 dB |
| Band Width | 25 kHz |
| Antenna Gain | 2 dB |
| Antenna Height | 2 m |
| System Loss | 1 dB |




Implementations:
- Tactical Combat Network
- Robust Operations in Urban and Multipath
- On-the-move Unit Communications
- Precision Timing / Geo-Localization

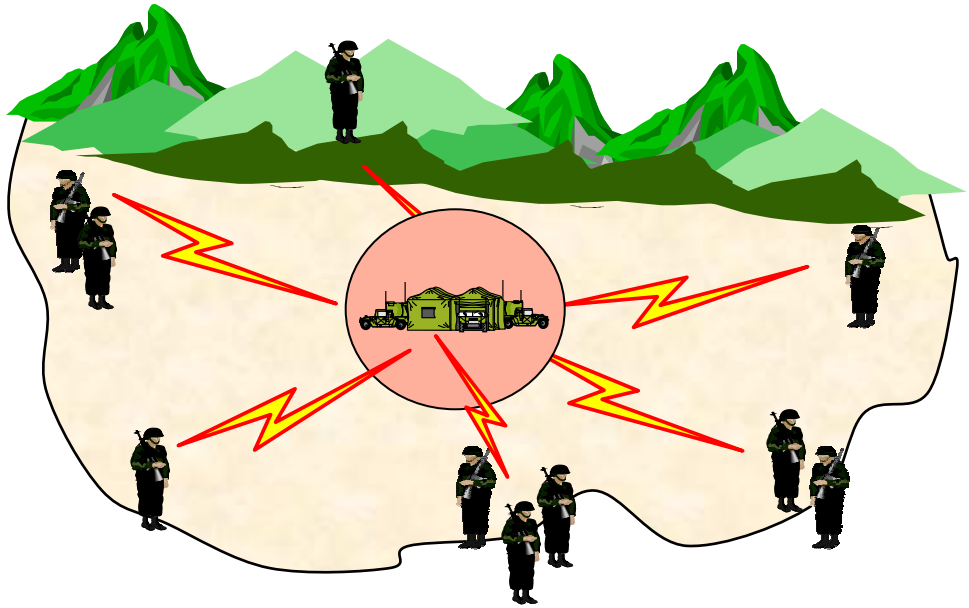
# High Data Rate – Short Range

## UWB Link Data

| | |
|---|---|
| Range | 100 m |
| Data Rate | 10 Mbps |
| S/N@ Max Range | 7 dB |
| Peak Power | 10 dBm |
| Pulse Width | 1 nsec |
| Center Frequency | 6.5 GHz |
| Bandwidth | 1 GHZ |
| Antenna Gain | 2 dB |
| Antenna Height | 2 m |
| System Loss | 1 dB |
| Noise Figure | 1 dB |

## EMI to Legacy Systems

| | |
|---|---|
| EMI Zone | 10 m |
| I/N | -9 dB |
| Noise Figure | 5 dB |
| Band Width | 5 MHz |
| Antenna Gain | -10 dB |
| Antenna Height | 2 m |
| System Loss | 1 dB |



Implementations:
- Unit Level Integrated Operational Picture
- Video to Foxhole
- Remote Surveillance Network

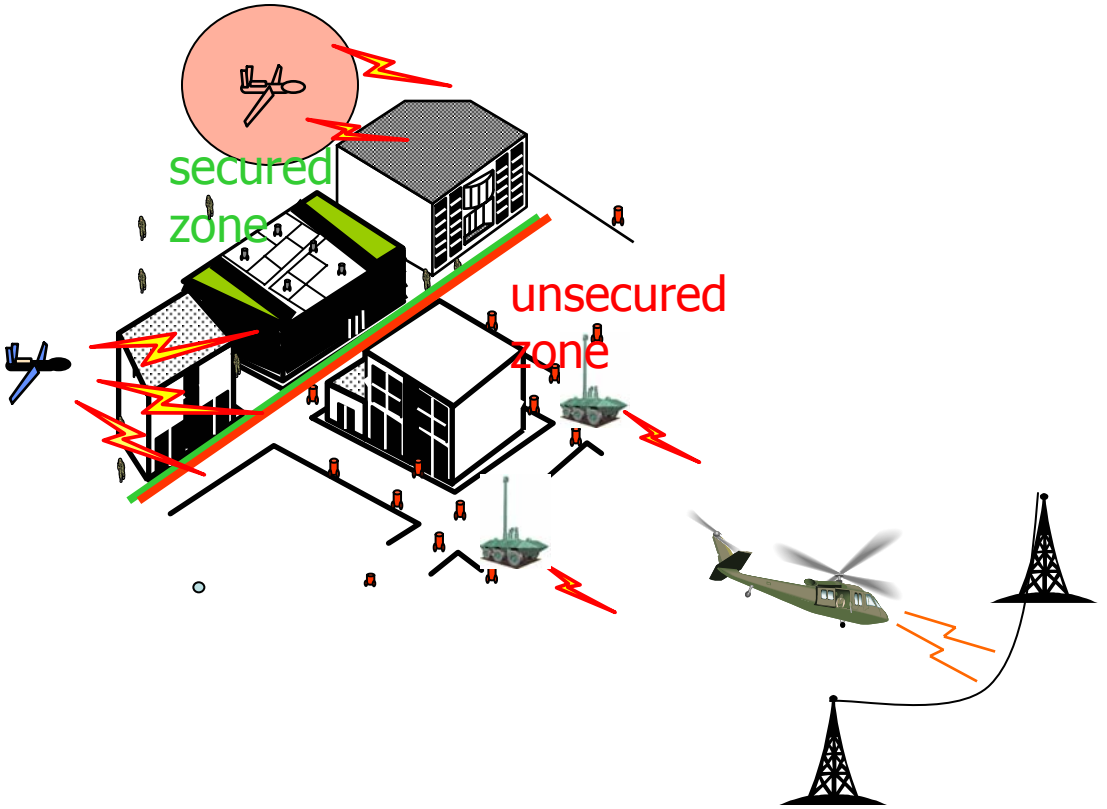
# UWB Radar

## UWB Radar

| | |
|---|---|
| Range | 500 m |
| Radar Cross Section | 1 $m^2$ |
| Pulse Repetition Rate | 10 Kpps |
| S/N@ Max Range | 2 dB |
| Peak Power | 40 dBm |
| Pulse Width | 1 nsec |
| Center Frequency | 6.5 GHz |
| Bandwidth | 1 GHZ |
| Antenna Gain | 24 dB |
| Antenna Height | 2 m |
| Noise Figure | 1 dB |
| Total System Loss | 2 dB |

## EMI to Legacy Systems

| | |
|---|---|
| EMI Zone | 10 m |
| I/N | -21 dB |
| Noise Figure | 5 dBm |
| Band Width | 5 MHz |
| Antenna Gain | -10 dB |
| Antenna Height | 2 m |
| System Loss | 1 dB |




Implementations:
- High Resolution Imaging
  - Through the Wall
  - Human detection
- Micro UAV/ROV Collision Avoidance
- Wire Detection

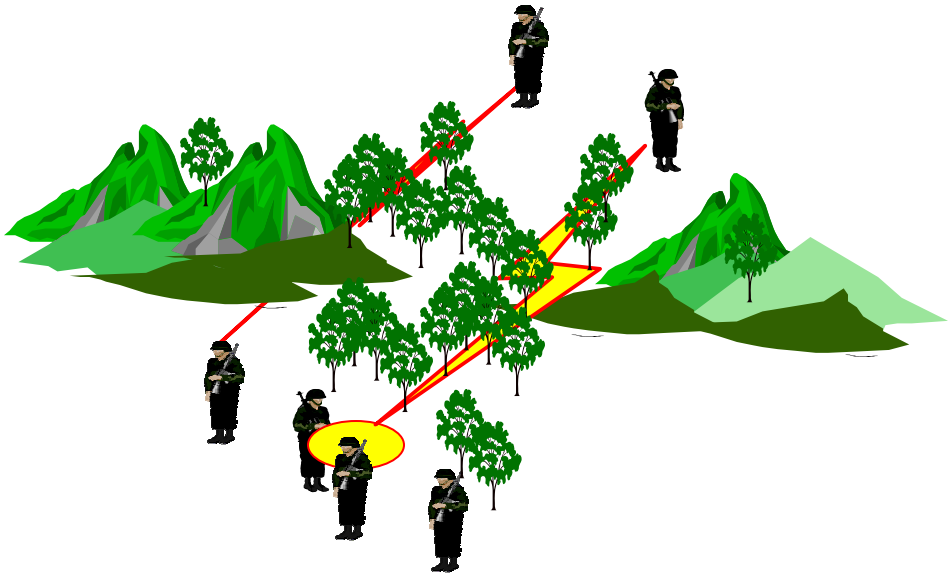
# UWB Personnel Radar

## UWB Radar

| | |
|---|---|
| Range | 100 m |
| Radar Cross Section | 1 $m^2$ |
| Pulse Repetition Rate | 100 pps |
| S/N@ Max Range | 6.6 dB |
| Peak Power | 50 dBm |
| Pulse Width | 3.3 nsec |
| Center Frequency | 850 MHz |
| Bandwidth | 300 MHZ |
| Antenna Gain | 2 dB |
| Antenna Height | 2 m |
| Noise Figure | 1 dB |
| Total System Loss | 1 dB |

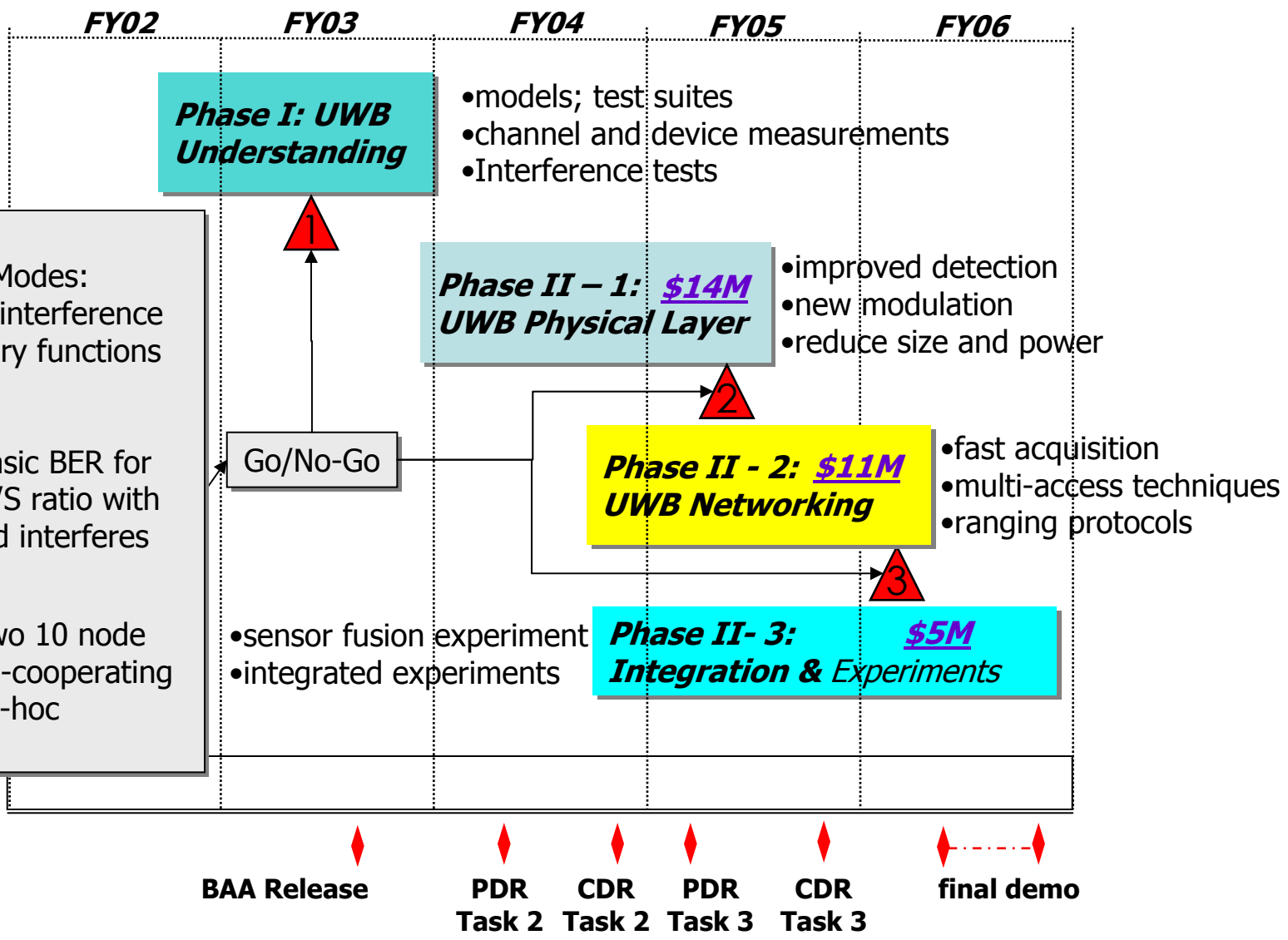
## EMI to Legacy Systems

| | |
|---|---|
| EMI Zone | 10 m |
| I/N | 20 dB |
| Noise Figure | 5 dBm |
| Band Width | 6 MHz |
| Antenna Gain | 2 dB |
| Antenna Height | 2 m |
| System Loss | 1 dB |



Implementation:
- Personnel Detection

# Netex Program Plan



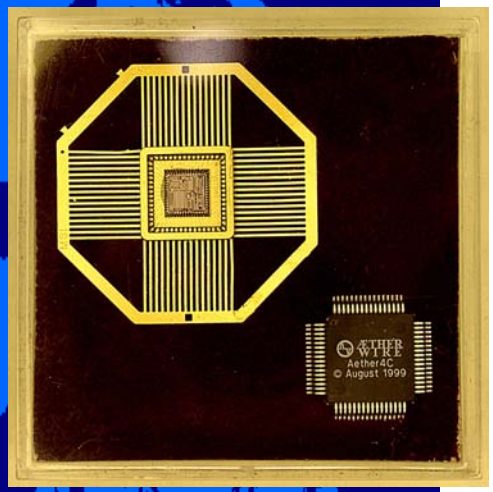

Phase I:
- Identify UWB Modes:
  - Do not cause interference
  - Support military functions

Phase II – 1:
- Achieve $10^{-3}$ basic BER for 80 dB (J+I+N)/S ratio with multiple in band interferes

Phase II – 2:
- Demonstrate two 10 node co-located, non-cooperating UWB mobile ad-hoc networks

# Task 2 UWB Physical Layer

Goal: Push UWB PHY layer design to the point where it is capable of reliably supporting advanced LPD, ranging, location and networking protocols.



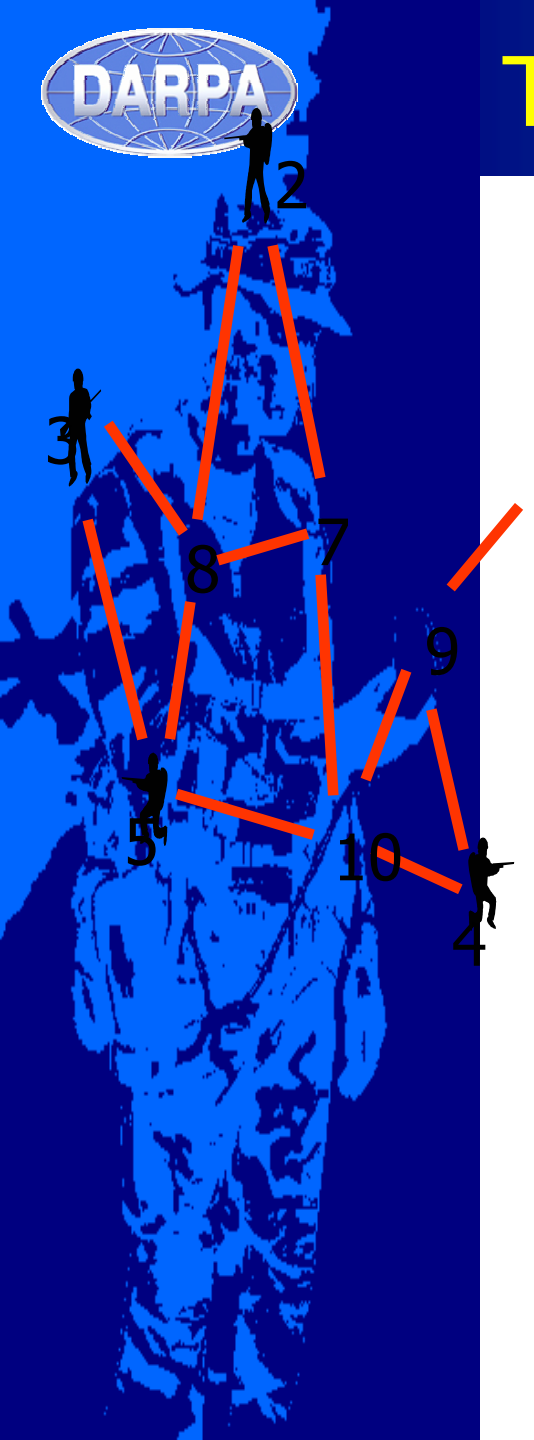

**Achieve $10^{-3}$ uncorrected BER for 80 dB (J+I+N)/S Ratio with multiple in band interferes**

**Challenges**

- **Integrate the lessons learned from the testing, modeling and simulations**
- **Coexist with legacy systems and intended jammers**
- **Develop improved detection, modulation and coding approaches to achieve 10-30 dB enhancement in system performance**
- **Develop interference excision techniques**
- **Develop simultaneous multi-function (comm, radar, timing and location)**
- **Develop robust LPD waveforms**

**Output: Small, reliable, deployable and affordable UWB radios for military networks**

# Task 3 UWB Networking




GOAL

Algorithms, Protocols, and Distributed Control for robust, scalable ad-hoc UWB networking

**Demonstrate two 10 node co-located, non-cooperating UWB mobile ad-hoc networks**

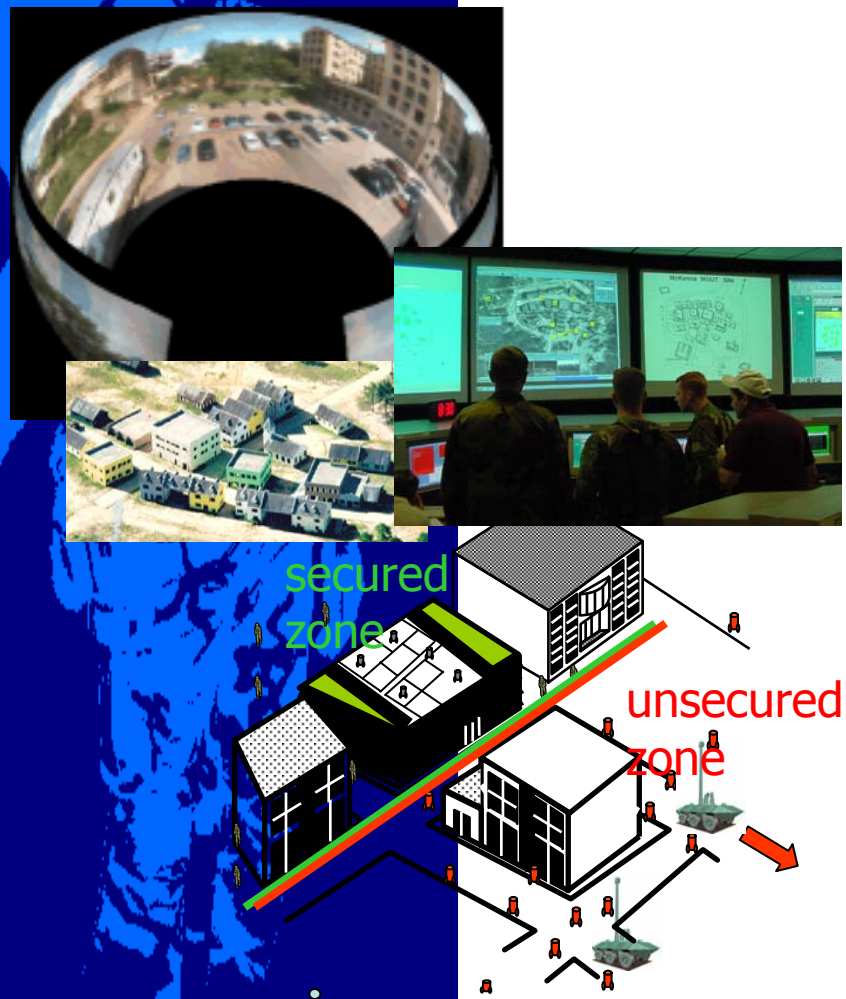
**Challenges**

- **precision time-based ad-hoc network**
- **self-organization & robustness using software adaptation**
- **modular design and open interfaces for `inter-stack' awareness**
- **simultaneous location, ranging, and comm**
- **extensible to density of 100 to >10,000 nodes in 1km$^2$**

**Output: Unique ad-hoc networking protocols that exploit the benefits of the UWB physical layer to provide robust communications**

# Task 4 Final Challenge Experiments

**Demonstrate 20 node hand held radios, 50 node video network and 50 node radar sensor integrated into high data rate short range network**




Hand held communications network

- 500 meters range
- 10 kbps data rate
- 2 days continuous operations

Video sensor network

- 100 meters range
- 10 Mbps data rate
- 30 days autonomous operations

UWB radar sensor integrated into network

- Detect 1 $m^2$ target
- 500 meters range
- 30 days autonomous operations



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